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SOUND TRANSMISSION LOSS PERFORMACE OF MUFFLER WITH CIRCULAR INLET AND VARIOUS NOZZLE SHAPED OUTLET CONFIGURATION

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ABSTRACT

This paper shows the details of measurement of the Acoustic Transmission Loss evaluation with circular inlet and tail pipe with nozzle shaped muffler configuration. This configuration analyzed by using Finite element Analysis (FEA). For these purpose the evaluation of transmission loss of different nozzle shape of tail pipe has been simulated by keeping constant volume of Expansion chamber. Also the design validation has been done with the existing results with same dimension to prove the compatibility of acoustical simulation. To observe the effect of transmission loss of circular cross-section expansion chamber with introduction of various nozzle shape tail pipe at by analyzing in FEA Acoustic Module. After the observation the results are compared in order to observe the effect of introduction of nozzle shape outlet in muffler.

KEYWORDS: Muffler, FEA Acoustic Module- Comsol, Transmission loss, same side inlet and outlet tail pipe, Nozzle shape outlet tail pipe.

1. INTRODUCTION

IC engines are typically equipped with an exhaust muffler (Silencer) to suppress the acoustic pulse generated by the combustion process. Vehicle engines generate more noise because of the pressure wave created during the sudden opening of the exhaust valves of the engine. A high intensity pressure wave generated by combustion in the engine cylinder propagates along the exhaust pipe and radiates from the exhaust pipe termination [1]. The noise is unwanted sound. Exhaust noise must meet legislation targets, customer expectations and cost reduction which requires for design optimization of the exhaust systems in the design phase. One of the components in the exhaust system of a vehicle is the muffler. The purpose of the muffler is to reduce the exhaust noise produced by the engine. Exhaust mufflers are designed to reduce sound levels at these frequencies [2].

In general, sound waves propagating along a pipe can be attenuated using either a dissipative or a reactive muffler. A dissipative muffler uses sound absorbing material to take energy out of the acoustic motion in the wave, as it propagates through the muffler. Reactive silencers, which are commonly used in automotive applications, reflect the sound waves back towards the source and prevent sound from being transmitted along the pipe. Reactive silencer design is based either on the principle of a helmholtz resonator or an expansion chamber, and requires the use of acoustic transmission line theory [3] [6].

There are several parameters that describe the acoustic performance of a muffler and it is associated piping. These include the noise reduction (NR), the insertion loss (IL), and the transmission loss (TL) [4]. The Noise Reduction is the sound pressure level difference across the muffler.[8] Though the Noise Reduction can be easily measured, it is not particularly helpful for muffler design. The Insertion Loss is the sound pressure level difference at a point, usually outside the system, without and with the muffler. Though the Insertion Loss is very useful to industry, it is not so easy to calculate since it depends not only on the muffler geometry itself but also on the source impedance and the radiation impedance. The Transmission Loss is the difference in the sound power level between the incident wave entering and the transmitted wave exiting the muffler when the muffler termination is anechoic; the Transmission Loss is a property of the muffler only. The muffler transmission Loss may be calculated from models but is difficult to measure [5].

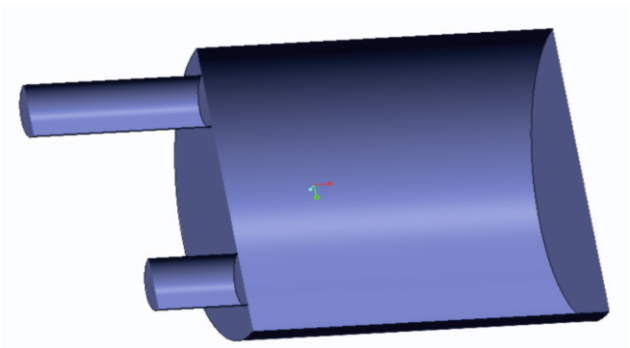


Figure 1: Single Expansion chamber with same side Inlet and Outlet

2. OBJECTIVES AND MODELLING

For evaluation of transmission loss of muffler the volume of Expansion chamber is keeping constant then changing the different shape of fillet. Here firstly validate the transmission loss measurement of existing system with the FEA result by using acoustical simulation tool which proves the compatibility of software [7]. To observe the effect of transmission loss of circular expansion chamber with introduction of nozzle shape outlet tail pipe at same side of inlet tail pipe.

Following design conditions are applied to analyzing the transmission loss of the simple expansion chamber:

1. Volume of the Expansion chamber is kept constant for all the modeling and designing work.
2. Modeling of circular expansion chamber by keeping the length of expansion chamber as constant i.e., 200 mm.
3. Modeling of circular expansion chamber by keeping the diameter of expansion chamber as constant i.e., 200 mm.
4. Modeling of circular expansion chamber by keeping the diameter of Inlet and Outlet tail pipe as constant i.e., 36 mm.
5. Modeling of circular expansion chamber by keeping the length of Inlet tail pipe as 100 mm and Outlet tail pipe as 50 mm.

Validation of the existing result with FEA Acoustic Module with same dimension

Z. Tao and A. F. Seybert used a circular expansion chamber having dimensions of diameter 6.035 inch, length 8 inch and tail pipe diameter 1.375 inch . The dimension and result is shown in fig.2. [2]

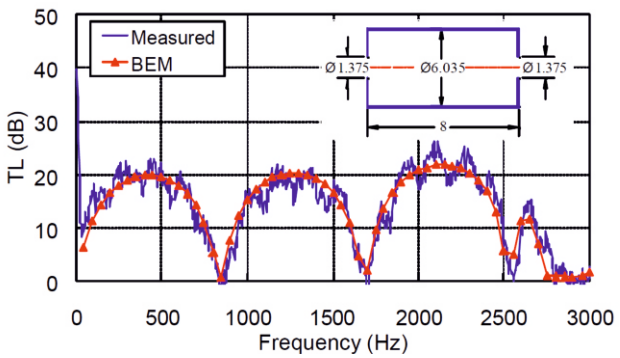


Figure 2: Existing geometry and Result of Transmission Loss of Simple Expansion chamber muffler

Transmission Loss measurement with FEA with same dimensions

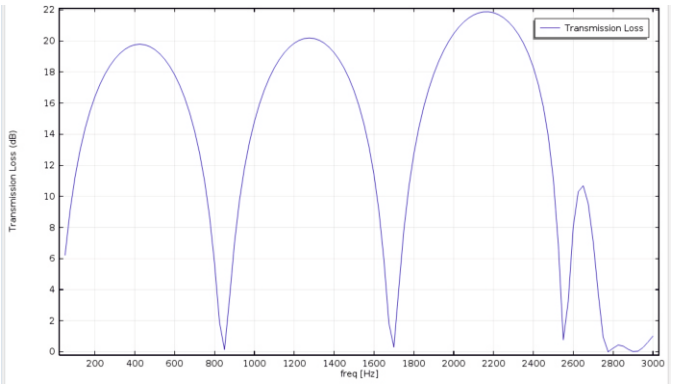


Figure 3: Result of Transmission loss of muffler with FEA

Transmission Loss measurement compared with FEA with existing same dimensions

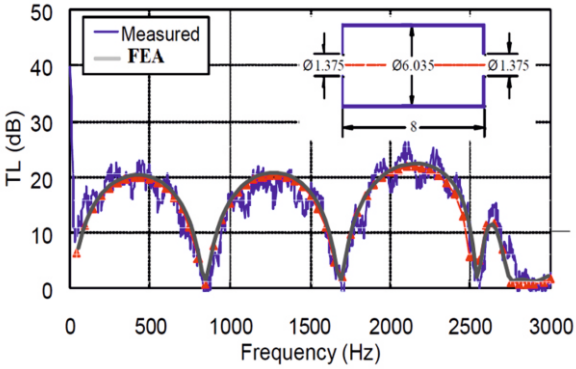


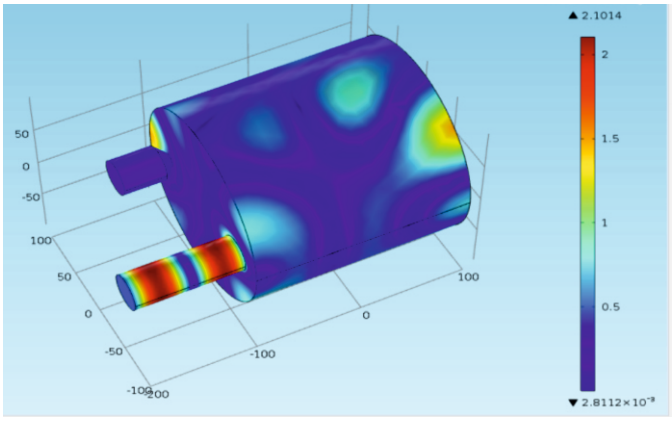
Figure 4: Result comparison for the validation of Transmission loss of muffler

Table 1. Modeling of circular expansion chamber for effect of transmission loss with introduction of nozzle shape outlet tail pipe:

S.No	Circular Expansion chamber outlet tail pipe length (mm)	Outlet tail pipe diameter connected with expansion chamber (mm)
1	L=50	36 mm both sides (Without Nozzle)
2	L=50	5 mm expansion chamber side and 36 mm at the end
3	L=50	10 mm expansion chamber side and 36 mm at the end
4	L=50	15 mm expansion chamber side and 36 mm at the end

Circular Expansion Chamber of Same side inlet and outlet with diameter and length of expansion chamber constant i.e.; 200 mm and Inlet Tail Pipe length constant i.e.; 100 mm

2.1 Effect of transmission loss with introduction of nozzle shape:
2.2.1 Same side inlet & outlet without Nozzle



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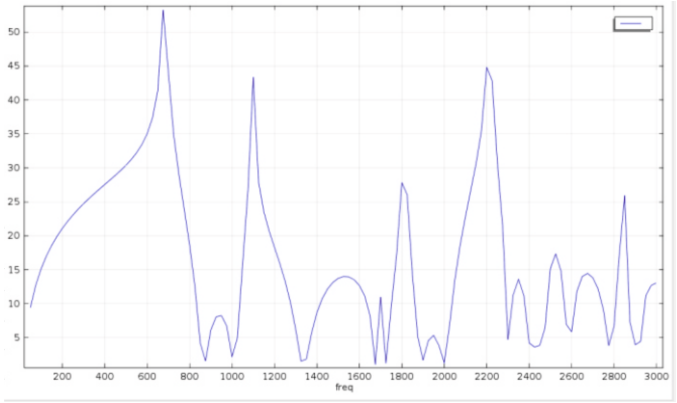
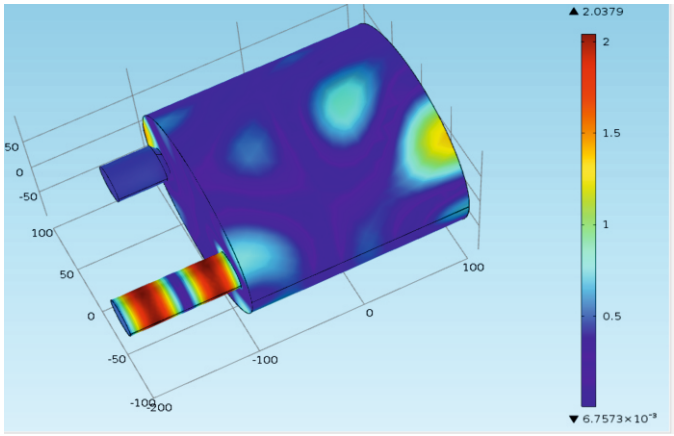


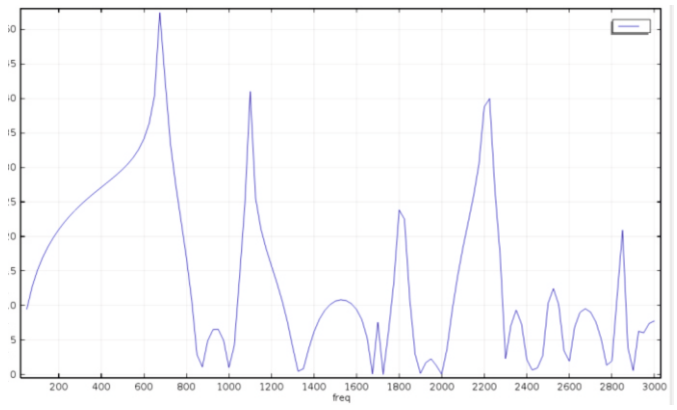
(b)

Figure 5: Analysis of Circular Expansion chamber (a) Absolute pressure (b) Transmission loss

2.2.2 5 mm expansion chamber side and 36 mm at the end



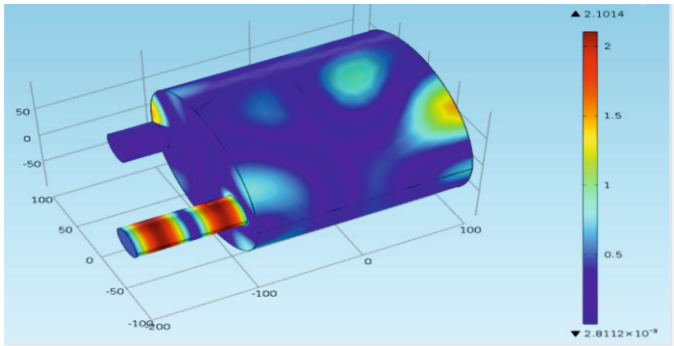
(a)



(b)

Figure 6: Analysis of circular Expansion chamber (a) Absolute pressure (b) Transmission loss

2.2.3 10 mm expansion chamber side and 36 mm at the end



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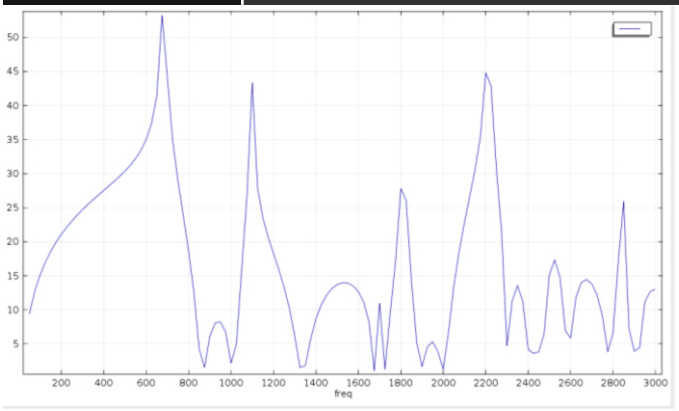
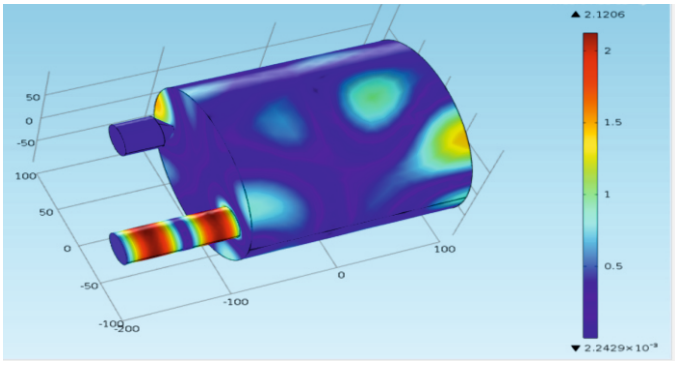


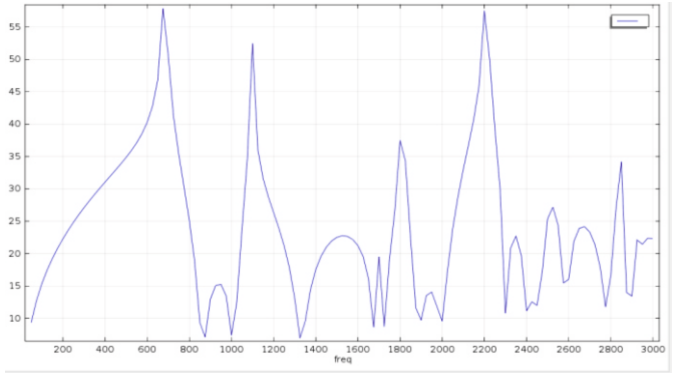
(b)

Figure 6: Analysis of circular Expansion chamber (a) Absolute pressure (b) Transmission loss

2.2.4 15 mm expansion chamber side and 36 mm at the end



(a)



(b)

Figure 7: Analysis of circular Expansion chamber (a) Absolute pressure (b) Transmission loss

3 RESULTS AND DISCUSSION

Table 2. Effect on Transmission Loss by the introduction of nozzle shape outlet tail pipe

S. No.	Circular Expansion chamber outlet tail pipe length (mm)	Nozzle shape outlet tail pipe (mm)	Average Transmission Loss (dB)	Average Acoustic Pressure (Pa)
1	L=50	36 mm both sides (Without Nozzle)	13.58	2.01
2	L=50	5 mm expansion chamber side and 36 mm at the end	14.24	2.03
3	L=50	10 mm expansion chamber side and 36 mm at the end	16.70	2.10
4	L=50	15 mm expansion chamber side and 36 mm at the end	23.90	2.12

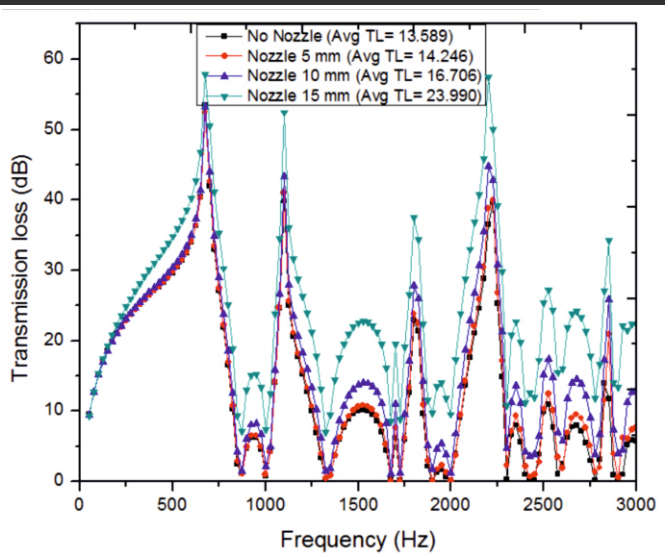


Figure 8: Transmission Loss for various circular expansion chambers with introduction of Nozzle shape outlet

4. CONCLUSIONS

The following conclusions are made with FEA results:

1. The analysis result of FEA is matched and validated with existing result.

2. By introduction of Nozzle shape outlet tail pipe to the muffler FEA results shows that the Transmission Loss for muffler having nozzle shape outlet of 15 mm is showing maximum attenuation as compared with other circular cross-section muffler having same volume and different nozzle shaped outlets.

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